R E P O R T R E S U M E S

ED 013 717 24 RE 000 322

THE DEVELOPMENT OF GRAPHIC ACTIVITY IN THE CHILD--A THEORY AND A FIRST EXPERIMENT.

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REPORT NUMBER BR-5-1213-1

EDRS PRICE MF-$0.25 HC-$0.76 19P.

DESCRIPTORS- REINFORCEMENT, *HANDWRITING DEVELOPMENT, HANDWRITING READINESS, *PRESCHOOL CHILDREN, *RESEARCH, *PERCEPTUAL DEVELOPMENT, WRITING SKILLS, VISUAL STIMULI, PICTORIAL STIMULI, GRAPHIC ARTS, *PERCEPTUAL MOTOR LEARNING, PSYCHOMOTOR SKILLS, CORNELL UNIVERSITY,

THE THEORY OF VISIBLE DISPLAYS IMPLIES A CONNECTION BETWEEN THE DEVELOPMENT OF PERCEPTION IN THE CHILD AND THE DEVELOPMENT OF HIS CAPACITY TO MAKE THINGS THAT STIMULATE PERCEPTION. TO VERIFY THIS, TWO STUDIES ON THE FUNDAMENTAL GRAPHIC ACT AMONG YOUNG CHILDREN CONSIDERED MOTIVATING FACTORS LIKE THE PLEASURE OF MOVING, KINESTHESIS, ACTIVITY DRIVE, AND VISIBLE DISPLAYS. ONE STUDY TESTED WHETHER THE ELIMINATION OF TRACE REDUCES SCRIBBLING ACTIVITY. FOURTEEN CHILDREN, 15 TO 38 MONTHS OLD, WERE ASKED TO SCRIBBLE IN A PLAY SITUATION WITH A NON-TRACING TOOL AND A REGULAR PENCIL. ALL THE CHILDREN SCRIBBLED LESS WHEN USING THE NON-TRACING TOOL. THIS SUPPORTS THE HYPOTHESIS THAT SCRIBBLING IS MOTIVATED BY THE SATISFACTION OF SEEING A TRACE OF THE MOVEMENT. A SECOND STUDY TESTED WHETHER SCRIBBLING IS A PURELY MOTOR ACTIVITY. ALL FOUR 3-YEAR-OLDS WHO WERE ASKED TO DRAW IN THE AIR WITH A TRACING TOOL REFUSED TO DO SO AND REQUESTED A PAPER TO DRAW ON INSTEAD. THIS DOES NOT GIVE CONCLUSIVE EVIDENCE THAT SCRIBBLING IS A PURELY MOTOR ACTIVITY. IT DOES INDICATE THE ROLE OF A RECORD OF THE TRACING MOVEMENT IN MOTIVATING THE FUNDAMENTAL GRAPHIC ACT AMONG VERY YOUNG CHILDREN. REFERENCES ARE GIVEN. (NS)

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RE 000 322 SEP 7 1967

BR-5-1213-1
PA 24
OEC-6-10-156

ED013717

The Development of Graphic Activity in the Child

A Theory and a First Experiment

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Introduction

The term graphic is used to describe both the skill of drawing and that of writing. Since these are quite different skills, the term can have different meanings. Both skills, however, develop from an eye-hand coordination that, although taken for granted, does not seem to have been analyzed by psychologists. It can be called the fundamental graphic act (Gibson, 1966, Ch. 11). It is defined as any kind of manipulation which leaves traces on a surface. One example is scribbling or finger-painting by a child, an act that leaves deposits on a surface, and another is scratching or grooving which leaves indentations on a surface, i.e., relief. A tool may or may not be used. A trace can be defined as an alteration in the light-reflecting capacity of a surface by changing either its color or its layout. According to "ecological optics," these are the two main ways in which a surface can structure light (Gibson, 1966, Ch. 10). The surface thus provides a new source of visual stimulation, a "display" in the general sense of the term.

The graphic act, like other kinds of manual activity, is progressive in time and thus entails several modes of proprioception or feedback, including visual feedback. It is visually guided. But the special characteristic of this kind of manipulation is the creation of the display--the persisting

record of the hand's movement as distinguished from the transient feeling and seeing of the movement. By means of the trace, a movement in time is converted into a form in space, the tracing growing as the graphic tool (or the hand itself) is moved over the surface.

It is assumed that the achieving of a display, the making of traces that can be looked at, is satisfying in its own right. We know that young children well before the age of 18 months enjoy scribbling, scratching, daubing, smearing, painting, and the like, with or without the use of a tool, and there is evidence to show that primates other than human also engage in this activity. Finger paintings or displays by apes have been exhibited.

The development of drawing and writing. The skill of drawing in the sense of depicting is assumed to develop gradually from the more fundamental act of trace-making. As the child discovers, or is taught, the elements of representation (such as the equivalence of lines on paper to the edges of objects in the world) and as he begins to recognize objects, places, animals, and persons in the pictures which surround him, he begins to name things in the drawings he makes and conversely to make drawings of things he can name.

The skill of writing also develops out of the graphic act, but at a later age. This skill depends on the learning of the grapheme-phoneme correspondences of the alphabet, i.e., on distinguishing the letters from one another and learning their vocal equivalents. At the outset, writing consists of the conversion of phonemes into graphemes and reading consists of the conversion of graphemes into phonemes. The two are reciprocal psychologically, but reading usually precedes writing in development. The drawing of letters,

either in the cursive or the printed style, requires a high order of trace-making skill, that is, a mastery of straightness, curvature, inclinations, angularity, openness and closedness of lines that has usually not been achieved by the six-year-old child, however much practice he has had in scribbling and drawing. Both depicting and later writing thus differentiate from the act of display-making. But the original undifferentiated graphic act, we may suppose, continues to develop and elaborate in the child independently of depicting and writing. It might be motivated by the mere pleasure of making traces to look at. There seems to be a satisfaction in creating forms even when they do not portray objects or specify speech. This motivation is often called esthetic and is claimed as the basis of art. It seems to be an interest in the producing and discriminating of optical structure for its own sake. "Doodling" in adults is not usually called art, but it has the same motivation.

The evolution of drawing and writing. In the history of man, as distinguished from the history of the child, there is good reason to believe that drawing and painting emerged about 20 or 30 thousand years ago with the discovery of the possibility of representation by the cave-dwellers. Writing, we know, emerged about five or six thousand years ago with the discovery of alphabets. Historically, as well as genetically, these skills developed out of trace-making. Evidence that the fundamental graphic act preceded the making of representative images is found on the same cave walls on which paintings appear, since doodling, designing, tracing, and hand-printing are preserved along with true representations.

It is interesting to note that the making of solid images, sculptures, seemed to develop at about the same time as the making of graphic images, pictures. This suggests that what might be called the fundamental plastic act, the shaping of a substance, had been practiced by man for countless ages along with the fundamental graphic act. We know, in fact, that the shaping of clay, stone, and wood into utensils and tools preceded the making of representative sculptures. The plastic act is psychologically similar to the graphic act, and there is no sharp line of division between the two kinds of visually-controlled manipulation, but we are concerned here only with the latter.

The motivation of depicting and writing as distinguished from that of displaying. It is assumed that the aim of the individual in making representations and in writing is to convey information to another individual or, more generally, to communicate. These are social acts, like speech, which existed of course in the human species long before representing and writing, and which also arises earlier in the child. The advantage of pictures and writing over speech is that they provide a lasting source of stimulation, a record, of the information conveyed. They do so by altering the light-reflecting capacity of a surface, thus affording an optic array to anyone who looks at it (Gibson, 1954). But it can be assumed that the aim of the undifferentiated graphic act is not to communicate or to convey information about the world. The motivation of trace-making is not social but individual. It is an exercise in the producing of variations of structure in an optic array, and in noticing them. Producing them is necessary for drawing and

writing; noticing them is necessary for the perceptions mediated by pictures and written words.

The development of mediated perception in the child. A distinction is implied between direct perception and mediated perception. The child's direct apprehension of the immediate environment develops as he does. He picks up more and more information from the light coming to his eyes from the world. But he also learns about the world, a larger world, by getting information at second hand. Pictures and writing (not to mention models and toys, which are not now considered) are important mediators of this indirect apprehension. The light to his eyes from a picture or a page conveys information about objects, places, events, animals and people besides information to specify the picture or page. He begins very early to detect the information from a picture or an image because the array is often quite similar to that from the natural source, to which his vision is already attuned (Hochberg and Brooks, 1962). Only much later does he learn to read--to pick up the information from writing--because, although he understands the speech equivalents, the alphabetic code is full of difficult visual discriminations (Gibson, Gibson, Pick, and Osser, 1962) and he must also learn the code itself. But the education of his attention to the basic graphic variations, to marks, traces, lines, and to the curves, slants, angles, intersections, and closures or gaps of lines (Hochberg, 1962), is surely facilitated if he has had practice in producing these variations by scribbling, tracing, drawing, and the like.

We do not usually say that the child must learn to understand pictures, as we say he must learn to read. The reason for this is probably that

pictorial perception does not entail the learning of a code whereas reading does. But the fact is that he must learn to detect the subtleties of visual structure, whether from picture, print, or from the environment itself, because it is the variations in the structure that convey the information. Herein lies the truth of the claim by artists that they can teach the rest of us to see (Kepes, 1944). They are concerned with visual structure as such and its power of evoking perception quite apart from whether the world is directly perceived, or is represented indirectly in a picture, or more indirectly by diagrams, or still more indirectly by alphabetic and numeric symbols.

Experiments suggested by this theory. The first thing to verify is the hypothesis that the fundamental graphic act in young children is motivated by trace-making. Scribbling might instead be motivated merely by the pleasure of moving, or by kinesthesis, or by an activity drive (Lowenfeld and Brittain, 1964). Assuming that normal children will scribble when given the opportunity, it is predicted that they will be unwilling to continue the act of moving a stylus over a surface when it fails to leave a visible trace. The control condition will be an otherwise identical tool which does leave a trace. The kinesthesis, including the feelings of the resistance and friction of the surface and the visible movement of the tool, should be the same in both conditions. The motor act and its concurrent proprioception will be the same. Only the lasting record of the movement, the new source of external perception, will be absent in the experimental condition.

A further prediction might be that young children will be still more unwilling to make tracing gestures in the air with no contact between stylus

and surface. The motor action is again the same, along with the kinesthesis in the traditional meaning of that term, but the haptic feelings of resistance and friction have been eliminated. Other experiments are suggested by this theory (for example, on the perception of trace-making by an object not under the voluntary control of the observer, and on the psychology of "copying" as compared to "free hand" drawing, and on the development of the contrast between "image" and "reality"), but these must be left to the future.

The Motivation of Trace-Making in Young Children

Study 1

The hypothesis to be tested is that children will be unwilling to move a stylus against a surface when it does not leave a trace, as compared with doing so when it does leave a trace, despite the equivalence of the two acts in all other respects. The relative amount of time spent scribbling with each of the tools is the principal index of motivation in this study. With such an index, it is possible to observe both verbal and preverbal Ss. A range of different ages and different amounts of scribbling experience was sampled to bring out possible developmental differences.

Method. Two identical manual tools, only one of which produced a trace, were compared. The nontracing tool was made from a wooden dowel, painted and shaped to look exactly like the tracing tool, which was a large, No. 2 lead pencil. Care was taken to make the tools equally sharp. (The experimenter could not distinguish between them on the basis of tactual feedback alone.) Double sheets of white paper, $11\frac{1}{2}$" x 17", were taped to

masonite boards of the same size. Ink embedded in the second sheet was released by pressure applied to the first; thus a record of the movement of the nontracing tool was obtained, although no trace was visible to the child when he used that tool.

Fourteen children, ranging in age from 15 to 38 months (mean age 28 months) were observed in their homes in a free play situation, with the mother and occasionally an older sibling present. Two Es were necessary to run the experiment, one to time the sessions, the other to direct the child's activity. To avoid creating a test-like atmosphere, instructions were minimized; the Es simply explained that they had brought some toys along because "they liked to watch children play." When rapport had been established, the child was seated at a table, on the floor, or in his mother's lap. The active E placed a paper-and-board before him and then handed him one of the tools, remarking that it was a very nice "pencil." Most Ss proceeded to scribble without further instruction; a few of the younger Ss responded only after a short demonstration of scribbling by E or an older sibling.

A stopwatch was started when S began to scribble and was stopped during those intervals when he was neither scribbling nor momentarily pausing to point out aspects of the scribble or otherwise talk about it. These pauses were very short, and since they occurred consistently and seemed to indicate interest in the task, they were considered as part of the time that the S engaged in scribbling activity. The session was terminated when S said he was finished, or asked for another paper, or stopped scribbling. However, if he desired to end the session before 10 seconds had elapsed, he was encouraged to "play a little longer." When S had scribbled for 90 seconds, he was

instructed to tell E when he was finished so he might be given some new material. (Pretests revealed that younger Ss were inattentive during the second session if permitted to scribble for more than 90 seconds during the first.) In the case of younger Ss who were either unable or unwilling to verbalize their desire to stop, repeated rejection of the tool or inattentiveness were taken as the criterion for ending the session; this procedure resulted in a slight overestimation of very short sessions. In most cases, S was not aware that the session was being timed, since the E who operated the stopwatch sat at some distance from him. Each S was given an opportunity to scribble with both tools, with the order of presentation alternating among Ss.

Results. Table 1 shows the amount of time in seconds during which each child engaged in scribbling with the tracing tool and the nontracing tool. Children are listed in order of increasing age. For all Ss, elimination of the trace reduced scribbling activity; the means were 71.7 seconds with the tracing tool and 20.6 seconds with the nontracing tool. The difference is significant. ($t = 5.35$, d.f. = 13, $p < .001$ 2-tailed)

Insert Table 1 about here

The following observations also support the hypothesis that a lasting trace must occur if scribbling is to be motivated. When using the tracing tool, Ss often called attention to their scribbles by pointing or naming, but this typical behavior did not occur when the tool left no trace. This is not, of course, surprising, but it shows the hypothesized importance of the

external display to the child. The common reactions to the nontracing tool included frequent examination of the tool or the paper, increased pressure (as judged by the heavier impressions left on the carbon sheet), puzzled looks at the Es, and distractableness. Furthermore, eight Ss made the source of their confusion explicit with such remarks as "This one can't work," "It's broken," or "This doesn't got ink!" It was also noted that, whereas scribbling without accompanying visual attention was rare, it occurred more often when the nontracing tool was used. Two Ss, for example, having discovered that the tool did not produce a trace, continued to move it very slowly across the paper but watched the Es disconcertedly. It was as if they expected some further trick to be played on them. Finally, there seemed to be a fairly consistent tendency for Ss to produce vertical or horizontal back and forth strokes with the nontracing tool, however complicated or advanced were their scribbles with the tracing tool. An interesting interpretation of this finding would be that Ss revert to a more primitive form of scribbling when using the nontracing tool (Lowenfeld and Brittain, 1964) but a simpler explanation is that the back and forth motion is simply the common procedure for "making a pencil write."

The data can be expressed as the ratio of the time used with the nontracing tool to the time used with the tracing tool $\left(\frac{\text{nontracing time}}{\text{tracing time}}\right)$. These ratios are also presented in Table 1. The amount of time spent with the nontracing tool was, on the average, only one-third that spent with the tracing tool. One might hypothesize, however, that if children scribble in order to achieve traces, they would not use the nontracing tool at all. This hypothesis was actually verified in four cases, numbers 6, 7, 12, and 13. These

children stopped as soon as they discovered that the tool did not "work." But it must be remembered that Ss were implicitly instructed to scribble by being asked to play with paper and with what appeared to be a pencil. Subject 11, for example, was very acquiescent, acting only at E's suggestion during the entire session. Although she scribbled with the nontracing tool longer than any other child, when asked at the end of the observations whether she liked that "pencil," she said she didn't like it because "it didn't write." Moreover, experience with graphic tools should create expectations which might lead Ss to try to make the pencil produce traces, i.e., some time was required to discover that the nontracing tool could not be made to leave visible traces.

The present hypothesis asserts that scribbling is motivated from the outset by the satisfaction of seeing a trace or display. An alternative hypothesis is that scribbling has only an activity motive at the outset and that the child has to learn to expect a trace following on the manipulation, after which it contributes to the motivation. On this latter hypothesis, tolerance of the nontracing tool should decrease with age and scribbling experience. However, the correlation between age and the measure of such tolerance (the ratio of time with the nontracing tool to that with the tracing tool) is not significant ($r = -.40$), although a slight trend in the appropriate direction is evident. This is not evidence to suggest that the satisfaction of seeing a trace depends on a learned expectation. There is other evidence, on the contrary, suggesting that the satisfaction is immediate and automatic. The behavior of the 16-month-old S (number 2) is regarded as particularly significant here, since she had had no experience with tracing tools prior to our observations (although she may have watched her older

brother scribbling). The child was first given the nontracing tool but could not be induced to scribble, even in imitation of her brother. She was next given the tracing tool. She responded as before--waving the tool and occasionally striking the paper with it--until an apparently fortuitous glance at the paper as she pounded it with the stylus. From that moment, the child scribbled, with great interest and increasing control. Although she had previously gripped the tool in her fist, she came to hold it overhand style. E presented the nontracing tool a second time at the first pause in the child's activity, since it was feared that her attention would wander before a comparison of the two tools could be made. This session was shorter and the child reverted to pounding the paper. It seems, then, that although she had not been taught the use of pencils nor the process of creating "pictures," her interest lay in the production of traces. When they were not forthcoming, scribbling stopped. It is likely that we observed in this child the first manifestation of scribbling, and this seemed to be a discovery of the fundamental graphic act.

Study 2

A test of the hypothesis that children scribble in order to indulge in motor activity for its own sake, or to make expressive movements for their own sake, would be to ask them to draw in the air with a tracing tool. They should be willing to do so, even after scribbling has been learned, if the act originated in this way. Motor kinesthesis is the same as that which accompanies moving a stylus over a surface, and the "visual kinesthesis" of seeing the hand-and-tool move is also the same. The graphic record is

eliminated, as in the previous experiment and also the concurrent feelings in the hand or the pressure and friction of the tool rubbing on the surface. The latter however are haptic accompaniments of graphic activity (Gibson, 1966, Ch. 7) and not strictly motor accompaniments.

In order to test this prediction, four three-year-old nursery-school children were asked the following questions:

Do you ever draw pictures in the air?

Can you make a picture of a _____ in the air with this pencil?

Show me how you do it.

If you pretend that there is a big piece of paper here, can you draw a picture? (Why not?)

Do you think this is a good way to make pictures?

(If the child refused to draw in the air, the fourth question was asked while the experimenter was doing so.)

All of the children refused to draw in the air, even when the activity was characterized as "make believe." These results cannot be attributed to a general unwillingness to perform because all of the children asked for paper on which to draw a "real" picture, one which they could "see." The prediction was not confirmed and this casts further doubt on the hypothesis that scribbling is a purely motor activity or that it begins as one.

Summary and Conclusions

Trace-making is defined as an eye-hand coordination--a visually controlled or guided manipulation like picking things up and putting them down--that has the characteristic feature of producing a display, a new external

source of visual stimulation which can be looked at by the producer and that continues to be visible not only to him but also to others. So conceived, the graphic act is not explained by the classical sense of kinesthesis nor by more recent ideas of visual feedback but requires new psychological assumptions. It seems a promising basis, however, for understanding the development of drawing and writing in the child--graphic communication in the broad sense of the term. It also makes intelligible the discovery by our prehistoric ancestors of pictures, pictographs, and alphabets. Depicting and writing are taken to be applications of the fundamental graphic act to forms of social communication that, unlike speech, span time and permit the accumulation of knowledge.

Trace-making in itself can become very elaborate, as graphic artists realize and can, by isolating the variables in a display, make our very perceptions of the natural environment more acute.

This theory of the origin of visible displays implies a connection between the development of perception in the child and the development of his capacity to make things that stimulate perception. The connection is not between perception and "motor action" or perception and "behavior," as behaviorists have argued. In learning to capture and freeze stimulus information on a surface the child is not learning to perform so much as he is to detect.

In order to verify this conception of graphic activity, two predictions were tested with young children at the age when they scribble, or begin to do so. First, if traces are essential to the act and the movements with their corresponding concurrent feedbacks are incidental, children should move less

when using a non-tracing pencil than they do when using a regular pencil. All children did so, and some refused to perform when they discovered that the tool did not trace. The difference appeared in one child who was said never to have scribbled prior to the experiment.

Second, if hand movements and their concurrent kinesthetic and visual feedbacks are sufficient for the act children should be willing to "draw a picture in the air." All of a small sample refused to do so even when encouraged and asked for paper.

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Table 1

Time Employed in Scribbling with Tracing and Nontracing Tools

Subject	Age (mo.)	Duration of activity (in seconds) Tracing Tool	Nontracing Tool	Proportion of time with nontracing to time with tracing tool
1	15	72	30	.417
2	16	22	16	.727
3	18	75	34	.453
4	22	35	15	.428
5	23	30	10	.333
6	25	72	3	.042
7	30	123	4	.033
8	30	55	29	.527
9	33	145	12	.083
10	35	90	41	.455
11	37	115	65	.565
12	37	53	5	.094
13	38	53	2	.038
14	38	64	23	.359
Mean		71.7 sec.	20.6 sec.	.325